植物分类学报 34(6):565～568(1996)
Acta Phytotaxonomica Sinica

三白草(三白草科)花部器官发生*

梁汉兴
(中国科学院昆明植物研究所,昆明 650204)
潘开玉　陈之端
(中国科学院植物研究所系统与进化植物学开放研究实验室,北京 100093)

FLORAL ORGANOGENESIS IN *SAURURUS CHINENSIS* (SAURURACEAE)

Ling Han-xing
(*Kunming Institute of Botany, Academia Sinica*, Kunming 650204)
Pan Kai-yu　Chen Zhi-Duan
(*Laboratory of Systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences*, Beijing 100093)

Abstract In the present study, floral organogenesis of *Saururus chinensis* was observed and compared with that of *S. cernuus*. The two species share essentially similar patterns of floral initiation and stamen development. Their inflorescence produces "common primordia" in acropetal succession on the flanks of the inflorescence meristem. Each primordium bifurcates transversely to form a floral apex above and a bract primordium below. Six stamens arise in three pairs at the floral apex. The median sagittal pair arises first, the lateral distal pair second, and the lateral proximal pair arises last. On the contrary, the initiation of carpels is quite different from each other. In *S. cernuus*, the median sagittal pair arises first, and the lateral pair next. In *S. chinensis*, however, the lateral pair arises first, and the median sagittal pair second. The present study also made a brief generalization using the data obtained from different fields on the relationship of the two species in the genus *Saururus*, which are disjunctly distributed between eastern Asia and North America.

Key words Floral organogenesis; *Saururus chinensis*

The eastern Asian-North American disjunct genus *Saururus* includes two species, *S. chinensis* and *S. cernuus*. It is considered as a primitive group in the family Saururaceae, and it is of close affinity with tropical Asian genus *Zippelia* in the Piperaceae.

The floral organogenesis of most species in the Saururaceae (*Saururus cernuus*, *Gym-*

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* The project was supported by the National Natural Science Foundation of China. The experiment was carried out at the Laboratory of Systematic & Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences.
The authors would like to thank Mr. Xiao Yin-hou for his assistance and valuable suggestions in SEM observation.
1996-01-17 收稿。

notheca chinensis, *Houttuynia cordata*, and *Anemopsis californica*) has already been studied by SEM (Liang *et al.*, 1989; Tucker, 1985, 1981, 1979, 1976, 1975). The floral vascular systems among the six species of the Saururaceae has been compared (Liang *et al.*, 1990). The bilateral symmetry and paired organ initiation occurring in the Saururaceae show no close relationship with Magnoliales, which is characterized by helical order of organ initiation. Saururaceous plants may represent a lineage in angiosperms which diverged very early. The further work conducted by Liang (1994) was a comparative study on floral organogenesis of the Saururaceae, which had revealed several evolutionary trends of changes in number, sequence and position of organ initiation. The major purpose of the present work is to find out the differences and connections between the two species in *Saururus*, with a hope that the result might be useful for understanding the evolutionary process of this genus following the segregation and divergence of the two floras.

1 Material and Method

Inflorescences of *Saururus chinensis* were collected two times, first from Mt. Omei, Sichuan, in May 1987, and second from Jinping, Yunnan, in March 1992. Inflorescence buds were dissected in the field and fixed in FAA. For observation with SEM, the materials were dissected again under a stereomicroscope, dehydrated in ethyl alcohol and then dried in a critical point dryer with carbon dioxide. The dried inflorescence and flowers were mounted on specimen stubes. Further dissection, e.g. removal of stamens which covered carpels, could be done on the stubs. The stubs holding the material were coated with gold. The specimens were observed under Hitachi S-800 SEM.

2 Results

2.1 Organography *Saururus chinensis* is a perennial with underground rhizome, growing in wet places often near ditches or ponds. One to three inflorescences are produced successively in a sympodial arrangement on each shoot. The inflorescences on a shoot develop successively. When the first is about 1 cm long, the second initiates. Inflorescences form in early March in southern Yunnan, but in May in Sichuan. During this period, all developmental stages of inflorescences may be found.

The inflorescence is a simple spike of 80～150 flowers formed in acropetal succession, with each flower subtended by a bract, but no perianth. Each hypogynous flower contains six stamens and four carpels.

2.2 Inflorescence Ontogeny The inflorescence primordium is derived from the terminal vegetative apex. Each inflorescence has flowers of different ages and sizes (Plate 1:1). The inflorescence apex is a highly convex dome, which produces numerous primordia on the flank in succession with the oldest at the base and the youngest at the summit. When a primordium increases in size up to 80 μm in diameter and roughly hemispherical, it begins to increase in length in tangential plane. Each primordium bifurcates into two parts, with a bract primordium below and a floral primordium above (Plate 1:2, 3). This primordium is termed "common primordium", because it includes both a floral apex and a bract primordium (Tucker, 1975). In *S. chinensis*, the bract primordium appears earlier, grows faster, and is larger than the floral apex at early stage (Plate 1: 3). It is different from *S. cernuus*, in which the floral apex and the bract primordium initiate simultaneously and are approximately equal in size at first.

2.3 Stamen Initiation The floral apex is convex and extends more quickly tangentially than radially (Plate 1:3). The organ which initiates first is the two median sagittal stamens (Plate 1:4). After initiation of the first two stamens, the lateral flanks broaden in the sagittal plane, and the lateral stamens initiate on either side of a flank. In general, the lateral distal stamens aries earlier than the lateral proximal ones (Plate 1:5, 9).

2.4 Carpel Initiation The sequence of carpel initiation in *Saururus chinensis* is entirely different from that in *S. cernuus*. The floral apex in the former is essentially flat when six stamens initiate. It increases mostly in the tangential plane. The carpel primordia initiate on the sides of the depression with the lateral ones forming first and remaining equal in size (Plate 1: 6, 7, 8). In *S. cernuus*, however, the floral apex expands in the median sagittal plane before carpel initiation. Carpels initiate in two decussate pairs. The first two carpels arise in the median sagittal plane, and then the second two arise in a plane crossing the first (Tucker, 1976).

3 Discussion

For studies on both systematics and biogeography, the Saururaceae is a very interesting family, and the genus *Saururus* is particularly worthwhile mentioning. This species pair (*S. chinensis* and *S. cernuus*) shows strictly eastern Asian-North American disjunct pattern in distribution, which is apparently ancient in origin, either in the Late Cretaceous or early Tertiary. They both retain many unspecialized features, such as apocarpy, hypogyny, carpels open during development, style and stigma grooved, stamens free, and pollen grains with anasulcate aperture. The previous data on morphology, anatomy, cytology and palynology have demonstrated that they have many similarities (Liang, 1992, 1991; Okada, 1986; Omor, 1982; Raju, 1961). The present work shows that they share the same pattern of floral initiation, in which the bract and floral apex originate from a common primordium and that stamen initiation follows a similar order. All these facts indicate that they are clearly descended from a common ancestor and their evolution is rather slow.

On the other hand, the present study has also discovered some transitional changes during the early stage of ontogeny, even some obvious divergences between the two species. For example, the initiation of lateral stamen pairs in *S. chinensis* is similar to that in the more advanced Asian genus *Gymnotheca*, although it has not yet formed a typical "common primordium" like that in *Gymnotheca*. The initiation time interval between the two lateral stamens is apparently shorter in *S. chinensis* than in *S. cernuus*. In several flowers of *S. chinensis*, the lateral stamens on each side of the floral apex are closer than those in *S. cernuus*.

Moreover, the order of carpel initiation is contrary between the two species as mentioned earlier in this paper. According to the comparative study on floral organogenesis of the four genera in the Saururaceae, median sagittal stamen and median sagittal carpel initiate first, which is a primitive character in the family. It seems that *S. chinensis* is a transitional form from primitive to advanced. In contrast, based on the comparative study of the floral vasculature in the family, the two species are different in the degree of fusion of vascular systems. The level of fusion between two ventral carpellary bundles and one dorsal carpellary bundle in each carpel is higher in *S. cernuus* than in *S. chinensis*. It seems to indicate that this more primitive feature has been maintained in *S. chinensis*.

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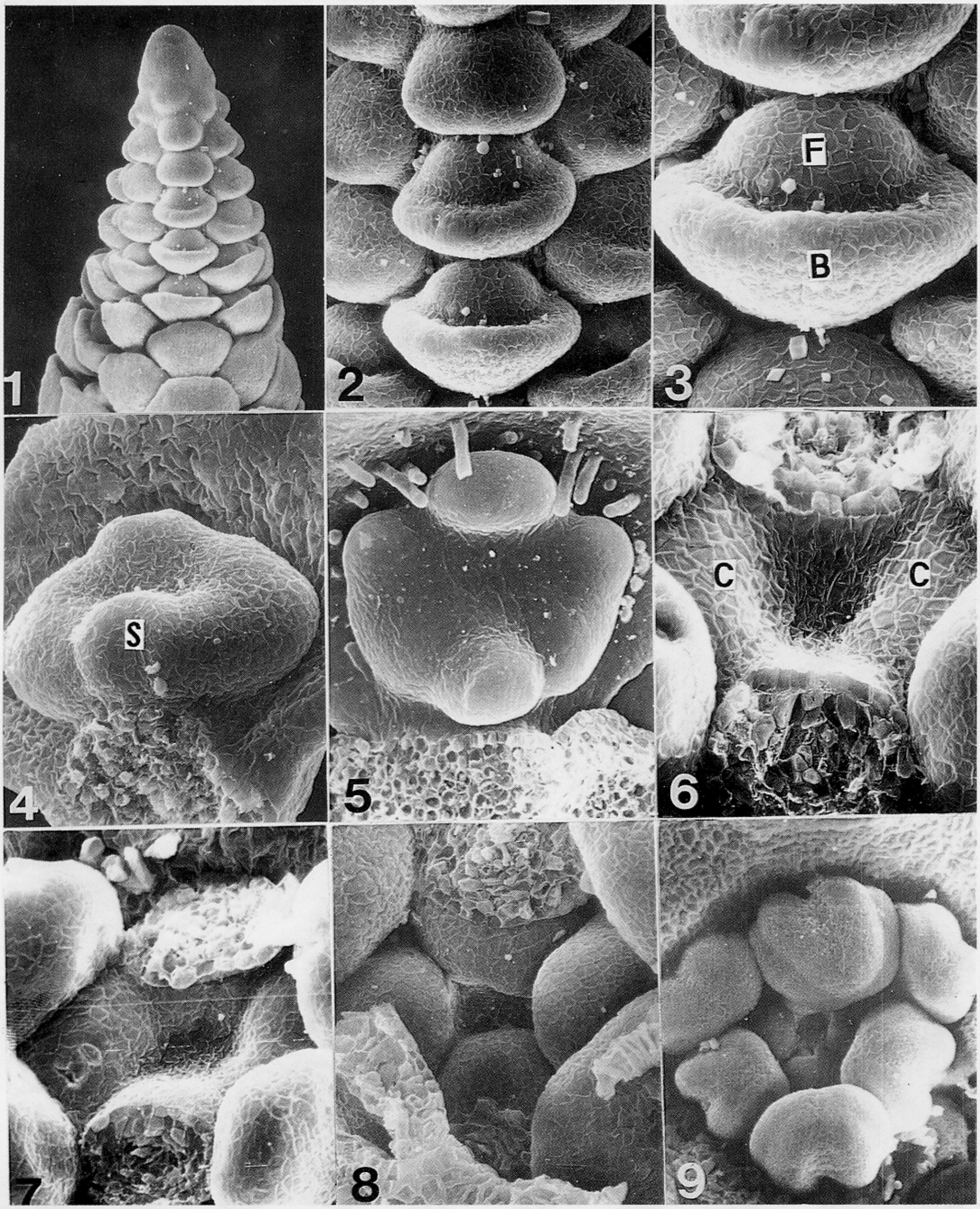
Explanation of Plate

Plate 1 1～3. Development of inflorescence of *Saururus chinensis*; 4, 5, 9. Intiation of stamen; 6～8. Initiation of carpel.



See explanation at the end of text